EXECUTIVE SUMMARY

FUNGICIDE BENEFITS ASSESSMENT

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January, 1991

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This Report Represents A Portion of the USDA/States
National Agricultural Pesticide Impact Assessment Program (NAPIAP)
Fungicide Assessment Project

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PREFACE

Plant diseases affect all the major food crops world-wide and must be controlled to prevent significant production losses and maintain food quality for animals and humans. In addition, fungicides are a necessary factor in maintaining the availability of fiber and landscape improvements ranging from forest management to enhancements through the use of ornamentals. Agricultural fungicides are a significant component in effective disease control and are critical to plant health management systems. Fungicides provide benefits to producers as well as consumers and to local as well as national economies. Farmers benefit from the prevention of yield losses, improved crop quality, enhanced market opportunities, facilitation of farmwork and harvest. Consumers also benefit from an ample, varied, safe, healthy and inexpensive food supply that is available throughout the year.

This Executive Summary was prepared from 11 separate reports that assessed the beneficial aspects of fungicide use in U.S. agriculture. The 11 reports, all using a commodity approach in evaluating fungicide use, comprise the Fungicide Benefits Assessment. This assessment represents one part of the USDA/States National Agricultural Pesticide Impact Assessment Program's Fungicide Assessment Project. The two other parts deal with (a.) a treatise examining the health and environmental factors associated with the agricultural use of fungicides, and (b.) an assessment of the status as well as the management strategies for fungal resistance to fungicides in the U.S.

The 11 Fungicide Benefits Assessment reports were prepared by a team of scientists (team leaders). Charles R. Curtis of The Ohio State University served as the project director. Nancy N. Ragsdale, University of Maryland, was coordinator representing the USDA. The team leaders and the listing of their reports (by commodity) in the Fungicide Benefits Assessment are as follows:

Team Leader	Commodity
John Ayers Department of Plant Pathology 211 Buckhout Laboratory The Pennsylvania State University University Park, PA 16802	**Turf**
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Appreciation is extended to members of the Planning Committee and many other collaborators who gave generously of their time and expertise in helping develop the project, reviewing report drafts, providing information and preparation of the various reports.

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Charles R. Curtis, Project Director
Nancy N. Ragsdale, Coordinator

January, 1991

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INTRODUCTION

Following release of a report by the National Academy of Sciences entitled, "Regulating Pesticides in Food: The Delaney Paradox" in which fungicides were highlighted as being particularly suspect as probable carcinogens, the Environmental Protection Agency (EPA) appeared likely to take regulatory action involving all or some of these compounds. The fungicides mentioned as most likely to be the targets of this action included the EBDC's (ethylenebisdithiocarbamates: maneb, mancozeb, zineb, etc.), captan, chlorothalonil and benomyl. Because these fungicides have such an important role in plant disease control, the National Agricultural Pesticide Impact Assessment Program (NAPIAP) initiated action to provide benefits information for use in an assessment. To our knowledge no comparable study has been accomplished.

The fungicides in question comprise approximately 80-90% of the fungicides used in the United States and play important roles in our agricultural production. They are highly effective in preventing destructive plant diseases and are important in numerous pest management programs. All of these fungicides with the exception of benomyl fall into the group of fungicides that have mechanisms of action at multiple sites within target organisms. This fact makes them extremely important in the management program utilizing newer fungicides with modes of action at very specific sites. These sites specific compounds are likely candidates for pest resistance problems when used alone. However, a variety of fungicides is critical to effectively control plant diseases.

Foremost among all benefits derived from the use of fungicides is the availability of an abundant and constant supply of high quality food and fiber. Fungicides are also necessary to protect foods from spoilage and contamination by harmful, naturally-occurring fungal toxins. Without fungicides the quantity and quality of the national food supply would be reduced with the danger of new diseases threatening our crops. The national importance of fungicides in plant health care has been emphasized through an official position statement, "Fungicides - Medicines for Plant Health" issued by the American Phytopathological Society, the leading international organization advancing modern concepts for managing plant health in agricultural, urban and forest settings. (See document on Pages 2 and 3).

To approach such a massive undertaking as the assessment of fungicide benefits in U.S. agriculture, a Planning Committee convened September 20, 1988, CSRS, Washington, D.C. Planning Committee members are listed in the Preface. The Planning Committee suggested that a commodity approach be taken with designated expert scientists, or team leaders, assigned to perform the fungicide benefits assessment. The relationship of the Planning Committee, team leaders and project organization is shown in Figure 1 (Page 4). Because of the number and wide variety of U.S. commodities to be surveyed, a strictly standardized reporting procedure was not possible for every report. However, where possible, reasonable uniformity of data and information was obtained and is presented in the individual team leader reports.

The American Phytopathological Society

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MEDICINES FOR PLANT HEALTH: FUNGICIDES

A position statement by The American Phytopathological Society
on the importance of agricultural fungicides
to the U.S. food supply

Plant Diseases Limit Food Production

As with people and animals, diseases develop in plants as a result of infection by pathogenic microorganisms. Plant diseases affect all major food crops world-wide and must be controlled to prevent production losses. In North America, plant diseases cause the loss of over 10% of total crop production despite the use of available controls. Much greater losses would occur without such controls. Diseases also significantly reduce food quality for both humans and animals.

Effective Disease Control Requires Several Practices

Effective plant disease control requires that several practices be combined into plant health management systems tailored to specific crops and locations. Crop rotation, sanitation procedures, tillage, disease-free planting stock, and disease-resistant varieties are basic components of these management systems. Agricultural fungicides are also key components. A fungicide is a pesticide used to protect seeds, roots, foliage, or fruit from infection by disease-causing fungi. Just as medicines are critical to maintaining human and animal health, fungicides as agricultural medicines are necessary to maintain, and sometimes restore, the health of agricultural crops.

Public Concerns

Recent public concerns about food safety and environmental quality have focused on exposure to pesticides or their residues and the adverse effects these might have on human health. Some have called for the elimination of specific pesticides, or pesticides in general. Often this is done with only a partial understanding of the extent to which diseases and pests limit our food supply, and the needs for crop protection.

Our Position on Fungicides

As plant health scientists, we advocate the following positions regarding the use of agricultural fungicides:

▶ **FUNGICIDES PROVIDE MANY BENEFITS** - When used prudently to protect plant health, fungicides benefit not only agricultural producers, but also the general public. The primary benefit is an abundant and constant supply of high quality agricultural products at reasonable prices. Fungicides also protect agricultural products from spoilage, and from contamination by harmful fungal toxins. Large-scale, commercial production of many crops, especially fruits and vegetables, requires the

use of fungicides in disease management systems. Without fungicides, the quantity and quality of our food supply would be reduced, and the chance of new diseases endangering our crops would increase. Commercial production of some crops would be completely eliminated in areas where humid weather favors disease. As a result, fruits and vegetables with unregulated exposure to pesticides may need to be imported to supply our markets.

▶ **REGULATION MUST BE SCIENCE-BASED** - Rigorous testing of new and current fungicides must be continued to identify hazards to human safety or characteristics that make them environmentally undesirable. In some cases, restrictions on use or a complete ban of certain products, may be necessary. However, just as the use of human medicines cannot be completely risk-free, neither can pesticide use. Only those fungicides that present minimal risks while providing significant benefits should be approved. Regulatory decisions about fungicides must be based on facts derived from recognized scientific procedures and not on public perceptions, emotions or speculation.

▶ **IMPROVED PLANT HEALTH MANAGEMENT SYSTEMS MUST BE DEVELOPED** - Research must continue to improve plant health management systems that combine several disease control procedures and minimize the use of fungicides. Improved systems will emphasize use of disease-resistant varieties, biological and cultural control procedures, and improved techniques for fungicide use. We endorse the development of new fungicides which are safe for human use, environmentally compatible, and cost effective. It is our judgement that improved plant protection systems will lessen future needs for fungicides, but that fungicides will continue to be critical components of modern plant health management systems for the foreseeable future.

▶ **EDUCATION IS CRITICAL TO SAFE PESTICIDE USE** - Education is the most important factor in the safe and environmentally responsible use of fungicides and other agricultural chemicals. The continued training and licensing of pesticide applicators, and education of farm workers is necessary to minimize exposure. The public needs accurate information on important issues facing modern agricultural production such as food safety, risk/benefit assessment, pest management alternatives, environmental impacts, and the responsible use of pesticides. It is only through a well-informed public that valid judgements can be made on the relative risks and benefits of pesticide use in maintaining our currently abundant, high quality, and relatively inexpensive food supply.

The American Phytopathological Society is a nonprofit organization of over 4500 U.S. and international scientists who study plant diseases and their control. It is an international leader in advancing modern concepts of plant health management in agricultural, urban, and forest settings.

Adopted August 8, 1990

Figure 1: The Fungicide Benefits Assessment Project

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NANCY N. RAGSDALE
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The Planning Committee Recommended Organizational Structure by Commodity Groupings

Selection of Commodity Team Leaders

COMMODITY	***TEAM LEADER***	***SUBCOMMITTEES***
Cereals	Greg Shaner, Purdue	Cereal Grains
Field Crops North	Gary Bergstrom, Cornell	Corn, cotton, soybeans, etc.
South	Tom Kucharek, Florida	
Fruits & Nuts East	Ken Hickey, Penn State	Almond, apple, peach, etc.
West	Doug Gubler, UC-Davis	
Turf	John Ayers, Penn State	Bermuda, blue-grasses, etc.
Vegetables East	Steve Johnston, Rutgers	Cucurbit, tomato, legumes, etc.
West	Mike Davis, UC-Davis	
Ornamentals (incl. forestry)	Chuck Krause, USDA-ARS	Greenhouse, nursery, landcapes, etc.
Regulatory	Narcy Klag, USDA-APHIS	Import/Export treatments
Special Case Studies	Paul Wuest, Penn State	Mushrooms

The Process

Team Leaders interacted directly with subcommittee members to assemble data for the commodity report.

Team Leaders synthesized the first draft of the Fungicide Assessment Report.

The Review Process

The Final Report
Publication Plan
Printing
Distribution

In this assessment, fungicides for the following commodities were evaluated at a national level: **Cereals, Field Crops (North and South), Vegetable Crops (East and West), Fruits and Nuts Crops (East and West), Ornamentals to include Forestry, Turf, Mushrooms and Regulatory Aspects.** The commodities involving **Field Crops** were arbitrarily divided into north and south to handle the assessment. Similarly the **Vegetable** commodities and **Fruits and Nuts Crops** were divided geographically into east and west components. An effort was made to cover the most significant uses of fungicides for these agricultural commodities. Limitations of time and resources prevented a more detailed study of all crops within the United States. However, efforts were made to cover the majority uses of fungicides and their importance in the agricultural production system. In examining the overall impacts, the commodity areas of **Fruits and Nuts** as well as **Vegetables** clearly emerge as the most critical uses of fungicides.

OBJECTIVES OF THE BENEFITS ASSESSMENT

1. To assemble and interpret information on the use of chemicals in agricultural practices to control fungal-induced diseases in agricultural products in the United States.

2. To provide information for determination of the biological and economic impact of fungicides on agricultural production and marketing from producer and consumer perspectives.

FIELD CROPS - NORTH (G. C. BERGSTROM) AND SOUTH (T. A. KUCHAREK)

These reports assessed the usage and agricultural benefits of fungicides on field crops. In the report titled **Field Crops-North** the following was covered: **field corn (commercial grain and silage production as well as hybrid seed production), popcorn, rape (canola) seed, sunflower, and forage legumes (including alfalfa and forage grasses).** In the report titled **Field Crops-South** the following were covered: **cotton, peanuts, soybeans, sugar beets, sugarcane and tobacco.**

Field corn and forage crop production are economically important in most regions of the United States. With the exception of seed production, field crops are extensively managed crops in which disease control is accomplished principally through selection of disease resistant cultivars and appropriate crop management methods. Although this situation is not expected to change substantially, cultural practices and genetic resistance alone often are insufficient to provide economic disease control. Fungicides have a legitimate and necessary role in integrated strategies to protect U. S. field crops from disease-induced reductions and yield quality.

There are essential needs that must be taken into consideration in any regulatory actions on fungicides used for field crops. These include seed treatment of corn (hybrid field corn, inbreds for seed production, and popcorn), foliar treatment of corn for leaf blights and rust, treatment of rape (canola) seed, seed treatment and foliar treatment for rust in sunflower, and treatments for root rot and damping-off in alfalfa. Cotton seed treatment is necessary; the use of chemical disease control after germination is highly dependent on weather conditions. Peanuts cannot be profitably produced without controlling foliar and seed diseases; yields would drop about 68% without the use of fungicides, and aflatoxin content would increase. Seed treatments are necessary for soybeans in some planting situations (cool soils, etc.); foliar fungicide use is limited due to soybean profit margins. However, fields produced for seed are sprayed more frequently because of the seed quality necessary for certification. Sugar beet production requires seed treatment; foliar applications are related to weather conditions. Sugarcane receives less fungicide treatment than any other agronomic crop; cultural controls and resistant varieties usually suffice. Foliar fungicide treatment is necessary for two major diseases of tobacco.

FRUITS AND NUTS - EAST (K. D. HICKEY) and WEST (W. D. GUBLER)

Commercial production of deciduous fruits and nuts in the U. S. comprises 3.37 million acres in various regions with an annual value of approximately $6.5 billion. This report shows the relative importance in usage patterns of the registered fungicides from the perspectives of regions east and west of the Mississippi River. Fruit and nut crops are susceptible to several hundred disease, insect, animal and weed pests requiring some level of control to prevent significant losses. Growers are very dependent on the use of agrichemicals to manage pests within economic injury levels. The establishment of action thresholds and the use of a number of factors

effecting the level of control are often integrated together into a management system known as Integrated Crop Management or ICM.

Because disease complexes vary with climatic regions and cultivars grown, specific Integrated Crop Management systems and fungicide rates must vary to match specific conditions. The development of pathogen strains which are tolerant to some fungicides such as the benzimidazoles, dicarboximides, or sterol biosynthesis inhibitors has presented major difficulties in maintaining control above economic injury level. While fungicides in these groups are still useful, their use must be in combination with products with different mechanisms of toxicity such as the broad-spectrum materials (captan, mancozeb, chlorothalonil, etc.).

These two reports discuss twenty-one crop groupings under the title of Fruits and Nuts. Hickey's report indicates that twelve deciduous fruit crops or groupings and pecans grown commercially in the United States east of the Mississippi River require annual fungicide applications for disease control. Each crop is affected with 6-12 major diseases causing economic losses each year if they are not controlled. Fungicide use from four to ten applications are essential for disease control because effective biological control is not available. Eighteen crops or crop groupings were covered in Gubler's report. These crops are grown commercially in the Western U.S. and require 1-14 fungicide applications, depending on the growing season, for protection against diseases. Each crop is affected by several diseases requiring the use of several fungicides or combinations of fungicides. Without satisfactory biological or cultural controls, the loss of currently used fungicides will have a significant impact in reducing yields resulting in increased costs to consumers of fresh fruit and nut products. Growers have quickly adopted Integrated Crop Management and Integrated Pest Management strategies in order to reduce fungicidal use. Efforts are continuing to utilize the minimum amounts necessary. However, fungicides are essential in these programs, and flexibility is required to meet constantly changing disease pressures.

Detailed and summary information is provided in both the East and West Fruits and Nuts Reports. The various crops or groupings discussed are as follows, but all groupings do not appear in both reports:

Almonds	Citrus	Peaches/Nectarines
Apples	Cranberries	Pears
Apricots	Grapes	Pecans
Bananas	Kiwi	Pistachios
Blueberries	Macadamia	Plums/Prunes
Caneberries	Mangos	Strawberries
Cherries	Papayas	Walnuts

VEGETABLES - EAST (S. A. JOHNSTON) AND WEST (R. M. DAVIS)

Vegetable disease incidence differs substantially between the Western and Eastern U. S. This is primarily because of differing environmental conditions in each of the areas. Humid, wet conditions of the Eastern U. S. mandate more intense use of fungicides to insure more disease-free produce. In contrast, the drier air conditions in the Western U. S. enable a lower frequency of fungicide use in most years. In order to market vegetables effectively, disease free produce must be provided. For fresh market vegetables, wholesale brokers or consumers at direct markets will not accept blemished vegetables. For processing vegetables, processors do not accept diseased produce in order to have a final product with a mold count below federal standards. For these reasons, growers have to protect their vegetables from diseases that not only lower yield but also lower quality.

Although many disease resistant varieties are used, fungicides are still necessary to control diseases in many situations. In some cases the resistant reaction (usually smaller lesions) in the acceptable variety can still lead to lower yield and poor quality. In other cases, diseases may be present in the area in which the varieties do not possess resistance and fungicide use is needed. Occasionally resistant varieties do not possess sufficient horticultural characteristics such that processors, brokers or consumers demand the use of the susceptible variety.

Disease forecasting systems are being used by growers to determine the frequency of fungicide applications. This has primarily been with Botrytis leaf blight in onion, early blight of tomato and late blight of white potato. During dry weather, fungicide schedules are extended and during other periods of favorable environmental conditions fungicide schedules are reduced.

The major fungicides used in vegetable production are the EBDC's and chlorothalonil. Benomyl is used to supplement control with EBDC's and chlorothalonil for certain diseases. Captan is a principle fungicide used for seed treatment and plant bed drenches to prevent damping-off of seeds and seedlings. The dicarboximide fungicides, iprodione and vinclozolin, are used to control Botrytis and Sclerotinia diseases. Metalaxyl is specific for downy mildew control in various vegetable crops. Triadimefon is used for control of powdery mildew in cucurbits.

Because the EBDC's and chlorothalonil have a broad spectrum of activity there is little possibility of pathogens developing resistance to these fungicides. In contrast, dicarboximides, metalaxyl and triadimefon are generally more effective on certain diseases. There is potential for resistance if they are used alone consistently. Specific fungicides are either formulated with an EBDC or chlorothalonil fungicide or in combination in spray schedules. The potential loss of EBDC fungicides presents a serious threat to the successful control of vegetable diseases. In crops such as peppers and spinach there are no adequate alternatives to EBDC fungicides. Also, for some vegetables such as white potato, the loss of EBDC fungicides places growers at an economic disadvantage forcing them to stop producing the crop since alternatives to

EBDC's are two to three times more expensive and the profit margin for potato is too low to be able to economically use the alternatives.

In the **Vegetables-East** report a narrative is presented on fungicide use of each of the 23 vegetables or vegetable groupings. Also included is a statistical summary of fungicide use by each state in the region. Specific vegetable fungicide use information included the following crops: **Asparagus, Beans, Beets, Carrots, Celery, Cole crops, Cucumber, Eggplant, Endive (Escarole), Leeks, Lettuce, Melon, Onions, Parsnips, Peas, Peppers, Pumpkins, Spinach, Squash, Sweet Corn, Sweet Potato, Tomato and White Potato.** The **Vegetables-West** report provides information on the following 16 vegetables or vegetable groupings: **Asparagus, Beans, Carrots, Celery, Crucifers, Cucurbits, Garlic, Lettuce, Onion, Peas, Peppers, Potatoes, Spinach, Sweet Corn, Sweet Potatoes, and Tomatoes.**

CEREAL CROPS (G. SHANER)

The objectives of the **Cereal Crops** study were to determine the percentage of cereal crops acreage (wheat, rice, barley, oats, and sorghum) and hops treated with foliar or seed fungicides each year in the United States, and to determine the impact of fungicides on control, prevalence and severity of diseases of these crops. The use of foliar fungicides on cereals is limited and practically nonexistent on barley, oats and sorghum. Genetic resistance has been the main control measure of the rusts in oats, barley and wheat. Therefore, except in certain situations where resistance is not available, fungicides have not been used to control these diseases.

Less than 7% of the U. S. wheat acreage receives foliar fungicides. However, in the Southeast and Pacific Northwest the percentage of treated acreage is much higher. This is a consequence of the higher yield potential in those areas compared to other major producing regions of the Southern and Northern Great Plains and the greater disease pressure in those areas. In the Pacific Northwest most of the foliar fungicide treatments are directed toward control of eyespot. Eyespot is not a serious problem in other parts of the country or where there is not an adequate genetic resistance available in adapted cultivars. In the Southeast, Septoria blotches and powdery mildew are often severe. There is some resistance to Septoria blotch and powdery mildew can be controlled with genetic resistance, but this resistance is conferred by single genes which are notoriously ephemeral because the fungus can rapidly overcome this resistance. Rusts can occur anywhere in the U. S. and are typically the most important cereal crop diseases in the Great Plains.

Even though fungicides currently have a minor impact on national production of wheat, they are quite important for certain regions of the United States. For example, wheat is the major crop grown in the Pacific Northwest and fungicides are used for eyespot control. The Southeast and the northern part of the Eastern soft wheat region has a higher wheat yield potential, much higher than that in the Great Plains. Wheat also provides an excellent rotational crop. This part of the country is the major supplier of soft wheats having different end product uses than the hard wheats grown in the Great Plains.

Rice is afflicted with sheath blight and blast in the humid Southeastern U. S. and Texas. Although resistance is available to most of the races of Pyricularia oryzae in the United States, adequate resistance to sheath blight is lacking. Many of the cultivars with the highest yield potential are susceptible to these diseases and growers find it economical to grow these cultivars and use a fungicide rather than rely on a resistant cultivar.

Both wheat and rice breeders work continually to incorporate resistance to all important diseases in the cultivar with high yield potential and good grain quality. In some cases only partial resistance may be all that is available or may be a better choice to avoid the genetic vulnerability from the use of high levels of resistance conferred by single genes. The strategy of using durable, partial resistance will be more effective if it is part of a disease management system including the option of using fungicides in years or geographic localities that favor disease development.

In terms of acres treated, seed dressings are the most common use of fungicides on wheat, barley and oats. The most common fungicide seed treatment is a mixture of carboxin and thiram (Vitavax 200), although thiram alone and quintozene are also used. Carboxin protects against bunt and loose smut, which are the principal seed-borne diseases of these crops. Seed treatment may also provide some protection against seedling blights caused by various fungi. Much of the rice seed sown in the U.S. is treated to control seed and seedling blights. Several different fungicides are used for this purpose.

Fungicides are important in the production of hops, which is grown in the Pacific Northwest. The main disease is downy mildew, and disease incidence is related to the weather conditions. Moisture is conducive to disease. A monitoring system is used to observe plant growth and weather conditions thus providing a management scheme for the use of fungicides on this perennial crop.

TURF (J.E. AYERS)

Losses due to turf diseases are extremely difficult to estimate. The only sub-commodity group that might be able to quantify losses in the traditional sense are turf farms. Based on the relatively small amount of fungicides used and acres treated, the diseases must be considered as a minor problem. In all other types of turf, losses would be in an aesthetic value. For these reasons, disease losses were not discussed in the report. Essentially 100% of the turf fungicides were applied as a foliar spray.

Fungicides are used for aesthetic purposes on lawns, golf courses and educational facilities. From an economic perspective, fungicides are used in sod production, grass seed production and seed treatment (predominantly in the South).

NURSERY CROPS (C. R. KRAUSE)

In this study, a determination was made of the amounts of specific nursery, greenhouse, landscape and flower species grown annually. In addition, estimates were made of percentages of crops affected by specific diseases, efficacy of fungicidal control according to specific labeled fungicides and alternative control procedures in lieu of chemical controlled products. Summary information is provided for **coniferous tree species, deciduous trees, greenhouse and shrubs**. While much of the data indicate injury or disease at 5 or 10%, apparently tolerable damage levels for other commodity groups are not acceptable for these nursery crops and represent substantial reductions in grower income.

MUSHROOMS (P. J. WUEST)

Commercial mushroom farming occurs in 24 states with major production zones in Pennsylvania (44%) and California (4%). Since 1983, the number of mushroom farmers has declined by 40%; yet, the total U.S. production has increased 26% by 1989 with 82% of the crop being sold as fresh mushrooms.

Mushroom pathogens are harbored in the wood of beds and trays, as well as being lodged in the crevasses of concrete blocks. Sanitation, hygiene, and exclusion remain the primary deterrence to insects and disease crop pests of mushrooms. However, there are diseases which are endemic to the crop. To control a host of fungal diseases, fungicides play an important role in production systems.

REGULATORY (N. KLAG)

The use of fungicides in regulatory activities is very limited. Certain commodities are required by law to be treated as a condition of entry into the United States. In some cases the commodity is treated upon inspection if treatable and harmful organisms are detected. Most fungicide-treated plant products offered for entry to the U.S. are for propagative purposes. In addition some countries require that certain commodities be treated with a fungicide as a condition of entry.

CRITICAL RESEARCH AND DATA NEEDS

Large knowledge gaps exist on the regional occurrence of diseases, disease-induced losses and overall fungicide benefits. Gaps also exist in comparative benefits of alternative fungicides, control practices and variety resistance. Reasons frequently cited for data gaps were insufficient funding and lack of professional recognition for crop loss assessment research in addition to the scarcity of state pesticide use and disease damage surveys. It is difficult to obtain the needed database to describe disease-loss relationships. Even when the models are developed they are often not applicable beyond the geographic area where they were developed. There is also a question of who is responsible for providing loss estimates. Should they be provided by a research or Extension faculty at Land Grant Universities and experiment stations or by personnel of state and federal departments of agriculture? If the assessment responsibility is assigned to one agency, how many scientists

are actually assigned to the project? Finally, there is a critical lack of funding for the research work needed to do the loss estimate, particularly at the regional and national levels.

In spite of the frequently cited need for disease loss estimates, there are surprisingly few available. Yet, perceptions are that these estimates are widely known and little attention has been given to the limitations of existing studies. "Plant diseases were initially studied because of the losses they cause, yet today it is paradoxical that there are only a few reliable estimates of loss."[1] The primary concern in applying fungicides is to protect crops or to reduce disease losses to an acceptable level. This level is often difficult to define but must be acceptable under current biological, economic and physical constraints.[2] Loss is defined as the measurable reduction in quantity, yield quality, or both. The relationship between loss and disease has not been studied intensively for many plant diseases. As a result, crop loss estimates are lacking at most organizational levels.

In almost all crops, economic losses are incurred under current management practices. This situation indicates a tremendous potential for crop improvement involving:

1. Cultural practices
2. Breeding for disease resistance
3. The use of fungicides in selective cases

Concerns about worker safety, public hazards and environmental quality should be continually addressed and emphasized through sound scientific research.

Finally, it would be extremely helpful to have this Fungicide Benefits Assessment periodically updated. As a valuable "first of its kind" document, serious efforts should be made to utilize the reports as a basic foundation or baseline document. Periodic surveys were ranked a high priority item in a recent study and evaluation of the pesticide assessment process.[3] The U.S.Department of Agriculture in conjunction with the American Phytopathological Society would be the logical partners in coordinating this massive national effort.

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[1] W. Clive James, 1974. Assessment of Plant Diseases and Losses. Annual Review of Phytopathology. 12:27-48.

[2] L. Campbell and L.V. Madden, 1990. Introduction to Plant Disease Epidemiology. John Wiley and Sons. 532 pp.

[3] Curtis, C.R., 1988. Agricultural Benefits Derived from Pesticide Use: A Study of the Assessment Process. The Ohio State University. 148 pp.